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Section 8.0 – LSD 41 Class Vessels: Compression Ignition Engines
in Whidbey Island Class

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SECTION 8.0 – LSD 41 CLASS

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8.0 LSD 41 CLASS

8.1 INTRODUCTION

This Environmental Effects Analysis Report (EEAR) evaluates surface vessel bilgewater discharge from the Uniform National Discharge Standards (UNDS) vessel group, “Large Compression Ignition Ships (6000 tons of displacement or more).” The USS WHIDBEY ISLAND Class (LSD 41) was selected as the representative vessel class for the group. This vessel class, combined with the USS HARPERS FERRY Class (LSD 49), also known as the LSD 41 cargo variant (Polmar, 1997), is one of the newest and largest classes (12 hulls) in the group. In addition, LSD 41 Class vessels use four compression ignition (CI) propulsion engines, which is the configuration used by half of the vessels within the group; others in the group use between one and five CI propulsion engines. The class is evenly distributed between the Pacific and Atlantic fleets. New vessels in the construction phase in this group include three BOB HOPE Class vessels (T-AKR 300) and four LPD 17 amphibious transport docks. For more information about the vessel group and the selection of the representative vessel class used in this environmental effects analysis (EEA), see *Vessel Grouping and Representative Vessel Class Selection for Surface Vessel Bilgewater/Oil-Water Separator Discharge* (Navy and EPA, 2001d).

Ships in this vessel group receive fluids in the bilge from many sources. These sources include condensate that forms on the interior hull and on piping, machinery condensate drains, leaking propeller shafts, pump packing glands, piping, valves, and flanges. The bilgewater may have oily constituents from diesel fuel marine (DFM) used for main engines and generators, and JP-5 fuel oil used to fuel helicopters. Other oily constituents include various lubricants such as 9250 lube oil (main engines and generators), 2190TEP lube oil (auxiliary equipment), synthetic lube oil (aircraft engines), hydraulic oil (elevators, cranes, and winches), and various grades of grease lubricants, used on pulleys, cables, valves, and other components.

Bilgewater discharges from the LSD 41 Class vessels were characterized from sampling data and supplemented by process knowledge from equipment experts and vessel drawings. Examples of sample data and process knowledge include end-of-pipe (EOP) chemical constituent concentrations, suspended solids and oil and grease (hexane extractable material (HEM)) concentrations, field measurements of pH, flow rates, and descriptive information such as color and odor. The Navy analyzed samples for constituent concentrations from the wastestream before processing (i.e., baseline discharge) and after marine pollution control device (MPCD) treatment. Details on the characterization of this discharge are contained in the *Characterization Analysis Report: Surface Vessel Bilgewater/OWS Discharge* (hereafter referred to as the Bilgewater Characterization Analysis Report (ChAR)) (Navy and EPA, 2003).

8.2 DIFFERENCES FROM THE EEA METHODOLOGY

The analysis of discharge information and presentation of results in this report are in accordance with the methodology contained in *Environmental Effects Analysis Guidance for Phase II of the Uniform National Discharge Standards for Vessels of the Armed Forces* (Navy and EPA, 2000e, hereafter referred to as the EEA guidance manual). The EEA for surface vessel bilgewater/OWS

discharge from Large Compression Ignition Ships (6000 tons of displacement or more) did not require any variation from the methodology contained in the EEA guidance manual.

8.3 SUMMARY OF EEA RESULTS

This section summarizes the results of the eight technical tasks conducted for the baseline discharge and each MPCD discharge.

8.3.1 Baseline Discharge

The baseline discharge has been subjected to a full EEA as a basis for comparing MPCD options; however, this vessel group does not release the untreated baseline discharge into the receiving waters. Currently, a gravity-coalescence OWS system processes bilgewater produced by this vessel group (see Section 8.3.2) prior to overboard discharge.

8.3.1.1 Discharge Characterization Data

Baseline discharge characterization data for Large Compression Ignition Ships (6000 tons of displacement or more) were assembled from sampling data and supplemented by process knowledge from equipment experts and vessel drawings. The sampling data for this vessel group were taken from USS WHIDBEY ISLAND (LSD 41 Class). The Bilgewater ChAR (Navy and EPA, 2003) contains more information on the collection and analysis of discharge characterization data.

The data analysis for this discharge identified 16 constituents of concern (COCs), two classes of constituents (i.e., a group of constituents such as total aromatic hydrocarbons), and six narrative categories in the baseline discharge. In accordance with the EEA guidance manual (Navy and EPA, 2000e), COCs are defined as:

- Constituents that exceed one or more numeric water quality criteria (WQC) at EOP or any narrative WQC;
- Constituents identified as bioaccumulative contaminants of concern (BCCs); or
- Constituents with EOP hazard quotients (HQ) > 1.

Appendix B lists the EOP concentrations of the COCs from the baseline discharge, their corresponding acute WQC, HQs at the edge of the mixing zone (EOMZ), and indicates whether they are elimination or reduction BCCs.

8.3.1.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for baseline discharge to numeric WQC, the EOP concentrations of 11 constituents or constituent classes exceeded 76 WQC (Table 8-1). Appendix A summarizes the comparison of the COC concentrations to corresponding Federal and State

WQC. The baseline discharge also exceeded six narrative WQC categories (Table 8-2). Appendix C provides the complete narrative WQC analysis.

Table 8-1. Constituents Exceeding Numeric Water Quality Criteria Identified in the Baseline Discharge¹ from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	Concentration at EOP (µg/L)	Criteria Exceeded	Strictest Criterion (µg/L)	State(s) with Strictest Criterion
Metals				
Copper	1.3E+01	22 of 24	2.4E+00	CT, GA, MS
Iron	3.4E+02	1 of 1	3.0E+02	FL
Lead	8.9E+00	1 of 11	5.6E+00	FL
Manganese	1.1E+02	1 of 1	1.0E+02	PR
Nickel	1.1E+02	22 of 24	8.3E+00	FL, NC PR
Thallium	1.5E+01	1 of 7	6.3E+00	FL
Zinc	4.1E+02	22 of 24	5.0E+01	PR
Organics				
Phenanthrene	1.1E+01	3 of 3	5.0E+00	PA
Total Aqueous Hydrocarbons	7.4E+01	1 of 1	1.5E+01	AK
Total Aromatic Hydrocarbons	2.4E+01	1 of 1	1.0E+01	AK
Nutrients/Classicals				
Ammonia as Nitrogen	1.2E+03	1 of 2	2.3E+02	WA

¹ Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated by a gravity coalescence OWS.

Table 8-2. Narrative Water Quality Criteria Categories Exceeded by the Baseline Discharge¹ from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Color	Fail
Nutrients	Fail
Phosphorus (6.0E+01 µg/L)	2.3E+02 µg/L
Ammonia (1.0E+01 µg/L)	1.2E+03 µg/L
Nitrate/Nitrite (1.5E+01 µg /L)	3.0E+03 µg/L
Total Nitrogen (3.0E+02 µg/L)	3.0E+03 µg/L
Odor	Fail
Oil and Grease (HEM)	Fail
EOP (5.0E+03 µg/L)	2.7E+04 µg/L
No Sheen (1.5E+04 µg/L EOP)	2.7E+04 µg/L
EOMZ (1.5E+01 µg/L)	1.4E+03 µg/L
Turbidity / Colloidal Matter	Fail

Narrative Constituent with Applicable Numeric Endpoint	Result
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¹ Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated by a gravity coalescence OWS.

8.3.1.3 Discharge Toxicity (Hazard Index)

Based on curvilinear-grid hydrodynamic 3D (CH3D) model results, the minimum dilution factor at the EOMZ for the baseline discharge was estimated to be 18.82. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E. For more information about the UNDS modeling method, see the *Technical Approach for Pierside Modeling to Support UNDS EEA Phase II* (Navy and EPA, 2001e).

Table 8-3 summarizes the results of the HQ and hazard index (HI) calculations for the baseline discharge constituents with an EOP HQ greater than 1. For more information on the use of the HI calculations in the UNDS program, see *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards (UNDS) Phase II* (Navy and EPA 2001f). The constituents are listed from highest to lowest HQ at EOMZ.

Table 8-3. Constituents with Hazard Quotients >1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Baseline Discharge¹ from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	HQ at EOMZ
Total Sulfide	8.4E+00
Copper	2.2E+00
Nitrate/Nitrite	2.2E+00
Oil and Grease (HEM ²)	1.7E+00
Sulfate	8.3E-01
Zinc	2.4E-01
Thallium	1.3E-01
Nickel	8.1E-02
Iron	6.0E-02
Manganese	5.7E-02
HI of above constituents	1.6E+01
Total Discharge HI	1.6E+01

¹ Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated by a gravity coalescence OWS.

² HEM TEC value was based on the fuel/lube TEC. For more information, see Development of TECs for Categories Derived from Petroleum and Foods (Navy and EPA, 2001g)

The discharge HI at EOMZ is approximately 16, with the above constituents comprising approximately 99 percent of the total discharge HI.

An HI of 1.0 or less is the level considered to be protective of aquatic life from acute toxic effects of the discharge. This level is equivalent to the United States Environmental Protection Agency (EPA) WQC for aquatic life [i.e., Criterion Maximum Concentration (CMC)]. The CMC is intended to protect most species most of the time (EPA, 1991). This level of protection is set near the concentration resulting in no observable effect on the most sensitive aquatic species, which EPA has determined will adequately protect aquatic communities. At HI values less than or equal to 1.0, the potential for acute toxic effects to aquatic species is considered to be at an acceptable level.

8.3.1.4 *Non-Indigenous Species Release*

The potential for the baseline discharge to introduce non-indigenous species (NIS) is expected to be low because “*there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances*” (EPA and DoD, 1999).

8.3.1.5 *Bioaccumulative Contaminants of Concern*

Table 8-4 lists the EOP concentrations of the seven constituents from the baseline discharge identified as elimination and reduction BCCs. BCCs for the UNDS program are divided into two types: those designated for elimination by various international, Federal, and State programs, and those designated for reduction by United States permit and cleanup programs.

Table 8-4. Bioaccumulative Contaminants of Concern Identified in the Baseline Discharge¹ from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Elimination BCCs (µg/L)		Reduction BCCs (µg/L)	
Cadmium	2.3E+00	Copper	2.0E+02
Lead	8.9E+00	Selenium	7.2E+00
		Zinc	4.1E+02
		Naphthalene	1.3E+01
		Phenanthrene	1.1E+01

¹ Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated with a gravity coalescence OWS.

8.3.1.6 *Constituent Mass Loading and Toxic Pound Equivalents*

Determination of discharge constituent mass loading and toxic pound equivalents (TPE) values are based on discharge generation volume and location of vessel operation. Vessels in the LSD 41 Class (representative vessel class) are pierside approximately 170 days per year, 5 days per year transiting inside 12 nm, and 190 days per year operating underway outside 12 nm (Navy and EPA, 2003).

Table 8-5 presents mass loading and TPE for the COCs identified in the baseline discharge for the active vessels in this vessel group while operating inside 12 nm. The COCs are listed from

highest to lowest TPE and comprise 97 percent of the total discharge TPE. Appendix F presents the complete discharge constituent mass loading and TPE data.

TPE results presented in Table 8-5 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible toxic weighting factor (TWF) for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 8.3.1.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately 11 percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents are assumed to contribute approximately 11 percent of the total chronic toxicity for this analysis.

Table 8-5. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Baseline Discharge¹ from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Total Sulfide	1.2E+03	3.3E+03
Copper	7.7E+01	1.4E+02
Nitrate/Nitrite	1.1E+03	1.1E+02
Nickel	4.3E+01	3.0E+01
Manganese	4.1E+01	2.5E+01
Zinc	1.6E+02	1.1E+01
Thallium	6.0E+00	5.3E+00
Ammonia as Nitrogen	4.8E+02	3.9E+00
Lead	3.4E+00	2.4E+00
Phenanthrene	4.4E+00	2.2E+00
Sulfate	1.9E+05	1.1E+00
Cadmium	9.0E-01	6.0E-01
Naphthalene	5.1E+00	2.4E-01
Iron	1.3E+02	2.2E-01
Selenium	2.8E+00	2.2E-01
COC TPE Total		3.6E+03
Total Discharge TPE		3.7E+03

¹ Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated by a gravity coalescence OWS.

8.3.1.7 Other Potential Environmental Impacts

Currently, all vessels in this group process bilgewater through a gravity coalescence OWS system before discharge. The environmental effects from the use of the gravity coalescence OWS are discussed in Section 8.3.2 below.

If CHT is employed, the baseline discharge is held onboard and then transferred to a shore facility for recycling or disposal without passing through an OWS system. The offloaded

bilgewater is then treated at a properly permitted facility and is subject to applicable Federal, State, and local disposal regulations.

8.3.1.8 *Summary of Environmental Effects*

The analysis of the baseline discharge from Large Compression Ignition Ships (6000 tons of displacement or more) identified 16 COCs, two constituent classes, and six narrative categories. Appendix B lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the baseline discharge:

- Exceeds 76 numeric WQC and six narrative criteria categories;
- Has an EOMZ HI of 16;
- Has low potential to introduce NIS;
- Contains two elimination and five reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 3,700, with the COCs comprising approximately 97 percent of the total.

8.3.2 Primary Treatment MPCD

For purposes of bilgewater analysis, gravity coalescence type oil water separators (OWSs) represent the three primary MPCD options determined to be feasible aboard the LSD 41 Class vessels (refer to Section 8.1).

As described in Navy and EPA (2000b), gravity coalescence type OWSs operate on the principle that due to the immiscibility and specific gravity differences of oil and water, the oil will separate from the water and droplets will coalesce into a separate layer of fluid. Oily waste is pumped from the oily waste holding tank (OWHT) through the OWS, which contains coalescing material. Coalescing material is typically polypropylene, an oleophilic polymer that may be in the form of closely spaced parallel plates or loose packed media. As the oil droplets, entrained in the influent, flow through the OWS, they will come into contact with the coalescing material and adhere to it. As more droplets attach to the polymer, they will come in contact with each other and form larger droplets (coalesce). These droplets will break free from the plates or media and rise to the surface of the OWS tank where they typically collect in an oil tower. The OWS has sensors that detect the presence of oil in the oil tower and trigger the OWS to automatically pump the collected oil to a waste oil tank. The treated effluent can be tested for oil content by an oil content monitor. If the effluent contains higher than the desired oil content, it may be returned to the OWHT for further processing. If the oil and grease (HEM) content of the effluent is less than 15 ppm, the effluent may be discharged overboard.

LSD 41 Class vessels use a 10-gpm gravity coalescence type OWS (Navy model OPB-10NP) to process bilgewater; consequently this option is the current MPCD. LSD 41 Class vessels use one

90-gpm pump to transfer both oily waste and waste oil to shore collection facilities. Gravity coalescers placed on Navy vessels are certified in accordance with NAVSEAINST 9593.2, OPNAVINST 5090.1B, and DoD Directive 6050.15. During normal pierside operation, LSD 41 Class vessel bilgewater is transferred to a shoreside treatment facility.

8.3.2.1 Discharge Characterization Data

Primary treatment discharge characterization data for Large Compression Ignition Ships (6000 tons of displacement or more) were assembled from sampling data and supplemented by process knowledge from equipment experts and vendors. The sampling data for this vessel group were taken from USS WHIDBEY ISLAND (LSD 41). The Bilgewater ChAR (Navy and EPA, 2003) provides more information on the collection of discharge characterization data.

The data collection for this discharge identified 16 COCs, two classes of constituents, and six narrative categories in the primary treatment discharge. Appendix B lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs.

8.3.2.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for the primary treatment discharge to numeric WQC, the EOP concentrations of 11 constituents or constituent classes exceeded 73 WQC (Table 8-6). Appendix A summarizes the comparison of COC concentrations to the corresponding Federal and State numeric WQC. The primary treatment discharge also exceeded six narrative WQC categories (Table 8-7). Appendix C provides the complete narrative WQC analysis.

Table 8-6. Constituents Exceeding Numeric Water Quality Criteria Identified in the Primary Treatment Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	Concentration at EOP (µg/L)	Criteria Exceeded	Strictest Criterion (µg/L)	State(s) with Strictest Criterion
Metals				
Copper	1.5E+01	22 of 24	2.4E+00	CT,GA,MS
Iron	3.3E+02	1 of 1	3.0E+02	FL
Lead	9.8E+00	1 of 11	5.6E+00	FL
Manganese	1.1E+02	1 of 1	1.0E+02	PR
Nickel	1.1E+02	22 of 24	8.3E+00	FL,NC,PR
Thallium	1.2E+01	1 of 7	6.3E+00	FL
Zinc	4.5E+02	19 of 24	5.0E+01	PR
Organics				
Phenanthrene	1.1E+01	3 of 3	5.0E+00	PA
Total Aqueous Hydrocarbons	7.7E+01	1 of 1	1.5E+01	AK
Total Aromatic Hydrocarbons	2.5E+01	1 of 1	1.0E+01	AK
Nutrients/Classicals				
Ammonia as Nitrogen	1.3E+00	1 of 2	2.3E+02	WA

Table 8-7. Narrative Water Quality Criteria Categories Exceeded by the Primary Treatment Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Color	Fail
Nutrients	Fail
Phosphorus (6.0E+01 µg/L)	1.5E+02 µg/L
Ammonia (1.0E+01 µg/L)	1.3E+03 µg/L
Nitrate/Nitrite (1.5E+01 µg/L)	3.4E+03 µg/L
Total Nitrogen (3.0E+02 µg/L)	3.0E+03 µg/L
Odor	Fail
Oil and Grease (HEM)	Fail
EOP (5.0E+03 µg/L)	2.2E+04 µg/L
No Sheen (1.5E+04 µg/L EOP)	2.2E+04 µg/L
EOMZ (1.5E+01 µg/L)	1.2E+03 µg/L
Turbidity/Colloidal Matter	Fail

8.3.2.3 Discharge Toxicity (Hazard Index)

Based on CH3D model results, the minimum dilution factor at the EOMZ for the primary treatment discharge was predicted to be 18.82. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input

parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E.

Table 8-8 summarizes the HQ and HI calculations for the constituents identified in the primary treatment discharge to have an HQ greater than 1 at the EOP. The constituents are listed from highest to lowest HQ at EOMZ.

Table 8-8. Constituents with Hazard Quotients > 1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Primary Treatment Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	HQ at EOMZ
Total Sulfide	7.4E+00
Nitrate/Nitrite	2.6E+00
Copper	2.0E+00
Oil and Grease (HEM ¹)	1.4E+00
Sulfate	8.2E-01
Zinc	2.6E-01
Thallium	1.0E-01
Nickel	8.1E-02
Iron	5.8E-02
Manganese	5.7E-02
HI of above constituents	1.5E+01
Total Discharge HI	1.5E+01

¹ HEM TEC value was based on the fuel/lube TEC. For more information, see Development of TECs for Categories Derived from Petroleum and Foods (Navy and EPA, 2001g)

The discharge HI at the EOMZ is 15, with the above constituents comprising approximately 99 percent of the total discharge HI.

8.3.2.4 Non-Indigenous Species Release

The potential for the baseline discharge to introduce NIS is expected to be low because “*there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances*” (EPA and DoD, 1999). The processing of the baseline bilgewater by a primary treatment MPCD will not increase, and may further reduce, the potential for the discharge to introduce NIS.

8.3.2.5 Bioaccumulative Contaminants of Concern

Table 8-9 lists the EOP concentrations of the seven constituents identified in the primary treatment discharge as elimination and reduction BCCs.

Table 8-9. Bioaccumulative Contaminants of Concern Identified in the Primary Treatment Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Elimination BCCs (µg/L)		Reduction BCCs (µg/L)	
Cadmium	2.4E+00	Copper	1.8E+02
Lead	9.8E+00	Selenium	7.1E+00
		Zinc	4.5E+02
		Naphthalene	1.5E+01
		Phenanthrene	1.1E+01

8.3.2.6 Constituent Mass Loading and Toxic Pound Equivalents

Table 8-10 summarizes the mass loading calculations and TPE for the COCs identified in the bilgewater treated by primary treatment for this vessel group while operating inside 12 nm. The COCs are listed from highest to lowest TPE and comprise approximately 97 percent of the total discharge TPE. Appendix F presents the complete discharge constituent mass loading and TPE data.

TPE results presented in Table 8-10 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible TWF for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 8.3.3.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately nine percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents are assumed to contribute approximately nine percent of the total chronic toxicity for this analysis.

Table 8-10. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Primary Treatment Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Total Sulfide	1.0E+03	2.9E+03
Copper	7.1E+01	1.3E+02
Nitrate/Nitrite	1.3E+03	1.2E+02
Nickel	4.3E+01	3.0E+01
Manganese	4.2E+01	2.6E+01
Zinc	1.7E+02	1.2E+01
Ammonia as Nitrogen	5.0E+02	4.0E+00
Thallium	4.6E+00	4.1E+00
Lead	3.8E+00	2.6E+00
Phenanthrene	4.2E+00	2.1E+00
Sulfate	1.9E+05	1.1E+00
Cadmium	9.2E-01	6.1E-01
Naphthalene	5.6E+00	2.6E-01
Selenium	2.7E+00	2.2E-01
Iron	1.3E+02	2.2E-01
COC TPE Total		3.2E+03
Total Discharge TPE		3.3E+03

8.3.2.7 Other Potential Environmental Impacts

Primary treatment creates two waste streams: the aqueous fraction that is discharged overboard, and the oil fraction that is directed to the onboard waste oil holding tank. The environmental impacts of the aqueous fraction are evaluated above. The oil fraction is treated ashore at a properly permitted facility and subject to applicable Federal, State, and local disposal regulations.

8.3.2.8 Summary of Environmental Effects

The analysis of the Primary Treatment Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) identified 16 COCs, two constituent classes, and six narrative categories. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the primary treatment discharge:

- Exceeds 73 numeric WQC and six narrative criteria categories;
- Has a discharge HI at EOMZ of 15;
- Has low potential to introduce NIS;

- Contains two elimination and five reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 3,300, with the COCs comprising approximately 97 percent of the total.

8.3.3 Primary Treatment plus Filter Media

For purposes of bilgewater analysis, gravity coalescence OWSs represent the three primary MPCD options for this vessel group (see Section 8.1). Secondary treatment options, such as the use of filter media, are therefore analyzed with gravity coalescence as primary treatment.

As described in the *Draft Surface Vessel Bilgewater MPCD Screen-Control Device, MPCD Option Group: Filter Media* (Navy and EPA, 2001a), filter media are substances that selectively remove constituents (e.g., organics and metals) from wastewater. The media have an affinity for a particular constituent(s). When passed through the filter media, these constituents can be removed, typically through adsorption and/or absorption, from bilgewater. The types of media studied for this MPCD option group include activated carbon, polypropylene, resin bonded glass fiber, cellulose, humic acid, and synthetic polymers. Aboard large vessels such as the LSD 41 Class, filter media are stored in multiple replaceable canisters used in series.

Primary treatment plus filter media is not currently practiced aboard vessels within this vessel group.

8.3.3.1 Discharge Characterization Data

Characterization data for Large Compression Ignition Ships (6000 tons of displacement or more) were assembled from sampling data and supplemented by process knowledge from equipment experts and vendors. The sampling data for this vessel group were taken from USS WHIDBEY ISLAND (LSD 41). The Bilgewater ChAR provides more information on the collection of discharge characterization data (Navy and EPA, 2003).

The data collection for this discharge identified 12 COCs, one class of constituents, and two narrative categories in the primary treatment plus filter media discharge. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs.

8.3.3.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for primary treatment plus filter media discharge to numeric WQC, the EOP concentrations of eight COCs or constituent classes that exceed 68 WQC (Table 8-11). Appendix A summarizes the comparison of the COC concentrations to corresponding Federal and State numeric WQC. The primary treatment plus filter media discharge also exceeded three narrative WQC categories (Table 8-12). Appendix C provides the complete narrative WQC analysis.

Table 8-11. Comparison of Constituent Concentrations Exceeding Numeric Water Quality Criteria for Primary Treatment plus Filter Media Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	Calculated Concentration at EOP (µg/L) ¹	Criteria Exceeded	Strictest Criterion (µg/L)	State(s) with Strictest Criterion
Metals				
Copper	1.5E+01	22 of 24	2.4E+00	CT, GA, MS
Lead	9.8E+00	1 of 11	5.6E+00	FL
Manganese	1.1E+02	1 of 1	1.0E+02	PR
Nickel	8.4E+01	22 of 24	8.3E+00	FL,NC,PR
Thallium	1.2E+01	1 of 7	6.3E+00	FL
Zinc	2.7E+02	19 of 24	5.0E+01	PR
Organics				
Total Aqueous Hydrocarbons	7.7E+01	1 of 1	1.5E+01	AK
Nutrients/Classicals				
Ammonia as Nitrogen	1.3E+03	1 of 2	2.3E+02	WA

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

Table 8-12. Narrative Water Quality Criteria Categories Exceeded by the Primary Treatment plus Filter Media Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Nutrients	Fail
Phosphorus (6.0E+01 µg/L)	1.5E+02 µg/L
Nitrate/Nitrite (1.5E+01 µg/L)	2.0E+03 µg/L
Ammonia (1.0E+01 µg/L)	1.3E+03 µg/L
Total Nitrogen (3.0E+02 µg/L)	3.0E+03 µg/L
Oil and Grease (HEM)	Fail
EOP (5.0E+03 µg/L)	6.5E+03 µg/L
No Sheen (1.5E+04 µg/L EOP)	6.5E+03 µg/L
EOMZ (1.5E+01 µg/L)	3.5E+02 µg/L

8.3.3.3 Discharge Toxicity (Hazard Index)

Based on CH3D model results, the minimum dilution factor at the EOMZ for the primary treatment plus filter media discharge was predicted to be 18.82. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E.

Table 8-13 summarizes the HQ and HI calculations for constituents identified in the primary treatment plus filter media discharge that have an HQ greater than 1 at EOP. The constituents are listed from highest to lowest HQ at EOMZ.

Table 8-13. Constituents with Hazard Quotients > 1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Primary Treatment plus Filter Media Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	HQ at EOMZ
Nitrate/Nitrite	1.5E+00
Copper	1.0E+00
Sulfate	8.2E-01
Oil and Grease (HEM ¹)	4.1E-01
Zinc	1.6E-01
Thallium	1.0E-01
Nickel	6.0E-02
Manganese	5.7E-02
HI of Above Constituents	4.2E+00
Total Discharge HI	4.2E+00

¹ HEM TEC value was based on the fuel/lube TEC. For more information, see *Development of TECs for Categories Derived from Petroleum and Foods* (Navy and EPA, 2001g)

The discharge HI at EOMZ is 4.2, with the above constituents comprising 99 percent of the total HI.

8.3.3.4 Non-Indigenous Species Release

The potential for the baseline discharge to introduce NIS is expected to be low because “*there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances*” (EPA and DoD, 1999). As discussed in Section 8.3.2.4, the processing of the baseline bilgewater by a primary treatment OWS may reduce the potential for the discharge of NIS to the receiving waters. While LSD 41 Class vessels may not currently use a secondary treatment device for bilgewater, the use of a secondary treatment option may further reduce the potential to release NIS.

8.3.3.5 Bioaccumulative Contaminants of Concern

Table 8-14 lists the EOP concentrations of the five constituents in the primary treatment plus filter media discharge identified as elimination and reduction BCCs.

Table 8-14. Bioaccumulative Contaminants of Concern Identified in the Primary Treatment plus Filter Media Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Elimination BCCs (µg/L)		Reduction BCCs (µg/L)	
Cadmium	2.4E+00	Copper	9.2E+01

Lead	9.8E+00	Selenium	7.1E+00
		Zinc	2.7E+02

8.3.3.6 Constituent Mass Loading and Toxic Pound Equivalents

Table 8-15 summarizes the mass loading and TPE for the COCs identified in the primary treatment plus filter media discharge for this vessel group while operating inside 12 nm. The COCs are listed from highest to lowest TPE and comprise approximately 62 percent of the total discharge TPE. Boron accounts for another 32 percent of the total discharge TPE. Appendix F presents the complete discharge constituent mass loading and TPE data.

TPE results presented in Table 8-15 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible TWF for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 8.3.3.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately ten percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents are assumed to contribute approximately ten percent of the total chronic toxicity for this analysis.

Table 8-15. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Primary Treatment plus Filter Media Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Nitrate/Nitrite	7.8E+02	7.3E+01
Copper	3.6E+01	6.5E+01
Manganese	4.2E+01	2.6E+01
Nickel	3.3E+01	2.2E+01
Zinc	1.0E+02	7.2E+00
Ammonia as Nitrogen	5.0E+02	4.0E+00
Thallium	4.6E+00	4.1E+00
Lead	3.8E+00	2.6E+00
Sulfate	1.9E+05	1.1E+00
Cadmium	9.2E-01	6.1E-01
Selenium	2.7E+00	2.2E-01
COC TPE Total		2.1E+02
Total Discharge TPE		3.4E+02

8.3.3.7 Other Potential Environmental Impacts

Primary treatment plus filter media creates three waste streams: the aqueous fraction that is discharged overboard following treatment, the oil fraction that is directed to the vessel's waste oil holding tank, and the solid waste composed of used filters. The environmental impacts of the aqueous fraction are evaluated above; there are no other known impacts to the receiving

environment. The oil fraction is treated at a properly permitted facility and the used filters are subject to applicable Federal, State, and local disposal regulations.

8.3.3.8 *Summary of Environmental Effects*

The analysis of the primary treatment plus filter media discharge from Large Compression Ignition Ships (6000 tons of displacement or more) identified 12 COCs, one constituent class, and three narrative categories. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the primary treatment plus filter media discharge:

- Exceeds 68 numeric WQC and three narrative criteria categories;
- Has a discharge HI at EOMZ of 4.2;
- Has low potential to introduce NIS;
- Contains two elimination and three reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 340, with the COCs comprising approximately 62 percent of the total.

8.3.4 Primary Treatment plus Membrane Filtration

For purposes of bilgewater analysis, gravity coalescence OWSs represent the three primary MPCD options for this vessel group (see Section 8.1). Secondary treatment options, such as the use of membrane filtration, are therefore analyzed as being used in conjunction with gravity coalescence.

As described in the *Surface Vessel Bilgewater MPCD Screen-Control Device, MPCD Option Group: Membrane Filtration* (Navy and EPA, 2001b), semi-permeable membranes are filtration systems that allow the passage of water, ions, or small molecules, but prohibit the passage of larger molecules (e.g., oil). Membrane filtration devices separate high molecular weight constituents from fluids by forcing the fluid through very small pores of a polymeric or inorganic membrane (LaGrega *et al.*, 1994). The membrane filtration MPCD option group consists of various types of membranes including nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF). Membrane filtration devices (NF, UF, and MF) are classified according to the size of the constituent they remove from the fluid.

8.3.4.1 Discharge Characterization Data

Baseline discharge characterization data for Large Compression Ignition Ships (6000 tons of displacement or more) were assembled from sampling data and supplemented by process knowledge from equipment experts and vendors. The sampling data for this vessel group were taken from USS WHIDBEY ISLAND (LSD 41). The Bilgewater ChAR provides more information on the collection and synthesis of discharge characterization data (Navy and EPA, 2003).

The data collection for this discharge identified 12 COCs, two classes of constituents, and five narrative categories in the primary treatment plus membrane filtration discharge. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs.

8.3.4.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for the primary treatment plus membrane filtration discharge to numeric WQC, the EOP concentrations of eight COCs or constituent classes exceeded 32 numeric WQC (Table 8-16). Appendix A summarizes the comparison of COC concentrations to the corresponding Federal and State numeric WQC. The primary treatment plus membrane filtration discharge also exceeded five narrative WQC categories (Table 8-17). Appendix C provides the complete narrative WQC analysis.

Table 8-16. Comparison of Constituent Concentrations Exceeding Numeric Water Quality Criteria for Primary Treatment plus Membrane Filtration Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	Calculated Concentration at EOP (µg/L) ¹	Criteria Exceeded	Strictest Criterion (µg/L)	State(s) with Strictest Criterion
Metals				
Copper	8.1E+00	21 of 24	2.4E+00	CT,GA,MS
Manganese	1.2E+02	1 of 1	1.0E+02	PR
Mercury	2.0E-01	3 of 12	2.5E-02	FL,GA,NC
Nickel	3.4E+01	3 of 11	8.3E+00	FL,NC,PR
Thallium	1.2E+01	1 of 7	6.3E+00	FL
Organics				
Total Aqueous Hydrocarbons	6.9E+01	1 of 1	1.5E+01	AK
Total Aromatic Hydrocarbons	2.0E+01	1 of 1	1.0E+01	AK
Nutrients/Classicals				
Ammonia as Nitrogen	5.4E+02	1 of 2	2.3E+02	WA

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

Table 8-17. Narrative Water Quality Criteria Categories Exceeded by the Primary Treatment plus Membrane Filtration Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Color	Fail
Nutrients	Fail
Phosphorus (6.0E+01 µg/L)	9.5E+02 µg/L
Ammonia (1.0E+01 µg/L)	5.4E+02 µg/L
Total Nitrogen (3.0E+02 µg/L)	1.1E+03 µg/L
Odor	Fail
Oil and Grease (HEM)	Fail
EOP 5.0E+03 µg/L	1.3E+04 µg/L
No Sheen (1.5E+04 µg/L EOP)	1.3E+04 µg/L
EOMZ (1.5E+01 µg/L)	6.9E+02 µg/L

8.3.4.3 Discharge Toxicity (*Hazard Index*)

Based on CH3D model results, the minimum dilution factor at the EOMZ for the primary treatment plus membrane filtration discharge was predicted to be 18.82. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E.

Table 8-18 presents the HQ and HI calculations for constituents identified in the primary treatment plus membrane filtration discharge to have an HQ greater than 1 at EOP. The constituents are listed from highest to lowest HQ at EOMZ.

Table 8-18. Constituents with Hazard Quotients > 1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Primary Treatment plus Membrane Filtration Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Constituents	HQ at EOMZ
Total Sulfide	6.1E+00
Oil and Grease (HEM ¹)	8.1E-01
Sulfate	7.4E-01
Copper	1.0E-01
Thallium	1.0E-01
Manganese	6.3E-02
HI of Above Constituents	7.9E+00
Total Discharge HI	8.0E+00

¹ HEM TEC value was based on the fuel/lube TEC. For more information, see Development of TECs for Categories Derived from Petroleum and Foods (Navy and EPA, 2001g)

The total discharge HI at the EOMZ is 8.0, with the above constituents comprising 99 percent of the total discharge HI.

8.3.4.4 *Non-Indigenous Species Release*

The potential for the baseline discharge to introduce NIS is expected to be low because “*there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances*” (EPA and DoD, 1999). The processing of the baseline bilgewater by a primary treatment MPCD will not increase, and may further reduce, the potential for the discharge to introduce NIS to the receiving waters. While LSD 41 Class vessels may not currently use a secondary treatment device for bilgewater, the use of a secondary treatment option may further reduce the potential to release NIS.

8.3.4.5 *Bioaccumulative Contaminants of Concern*

Table 8-19 lists the concentrations of the five constituents from the primary treatment plus membrane filtration discharge identified as elimination and reduction BCCs.

Table 8-19. EOP Concentration of Bioaccumulative Contaminants of Concern Identified in the Primary Treatment plus Membrane Filtration Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Elimination BCCs (µg/L)		Reduction BCCs (µg/L)	
Mercury	2.0E-01	Copper	9.4E+00
		Selenium	6.6E-04
		Zinc	1.9E+01
		Naphthalene	2.0E+01

8.3.4.6 *Constituent Mass Loading and Toxic Pound Equivalents*

Table 8-20 summarizes the mass loading calculations and TPE for the COCs identified in the primary treatment discharge for this vessel group while operating inside 12 nm. COCs are listed from highest to lowest TPE and comprise approximately 96 percent of the total discharge TPE value. Appendix F presents complete constituent mass loading and TPE data.

TPE results presented in Table 8-20 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible TWF for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 8.3.4.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately ten percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents are assumed to contribute ten percent of the total chronic toxicity for this analysis.

Table 8-20. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Primary Treatment plus Membrane Filtration Discharge from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Total Sulfide	8.4E+02	2.3E+03
Manganese	4.6E+01	2.8E+01
Nickel	1.3E+01	9.0E+00
Mercury	7.9E-02	9.2E+00
Copper	3.6E+00	6.6E+00
Thallium	4.6E+00	4.1E+00
Ammonia as Nitrogen	2.1E+02	1.7E+00
Sulfate	1.7E+05	9.6E-01
Zinc	7.2E+00	5.0E-01
Naphthalene	7.7E+00	3.6E-01
Selenium	1.4E+00	1.1E-01
COC TPE Total		2.4E+03
Total Discharge TPE		2.5E+03

8.3.4.7 Other Potential Environmental Impacts

Primary treatment plus membrane filtration creates two waste streams: the aqueous fraction and the oil fraction. The aqueous fraction is evaluated above; there are no other known impacts to the receiving environment. The oil fraction is treated at a properly permitted facility.

8.3.4.8 Summary of Environmental Effects

The analysis of the primary treatment plus membrane filtration discharge from Large Compression Ignition Ships (6000 tons of displacement or more) identified 12 COCs, two constituent classes, and five narrative categories. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the primary treatment plus membrane filtration discharge:

- Exceeds 32 numeric WQC and five narrative criteria categories;
- Has a discharge HI at EOMZ of 8.0;
- Has low potential to introduce NIS;
- Contains one elimination and four reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 2,500, with the COCs comprising approximately 96 percent of the total.

8.3.5 Collection, Holding, and Transfer (CHT)

Collection, holding, and subsequent transfer of bilgewater involves either shore disposal facilities or waste offload barges, or processing of bilgewater beyond 12 nm. Shore disposal involves transfer of wastes to properly permitted treatment facilities either directly through a shoreside piping connection, or via tank trucks or waste offload barges. CHT does not include any treatment or volume reduction of raw bilgewater on board the vessel. In a typical CHT system, wastewater drains to the bilge or is transferred to a designated holding tank where it is retained until either the vessel returns to port or transits beyond 12 nm.

CHT is in use, to some extent, on all vessels that generate bilgewater, including the LSD 41 Class. All LSD 41 Class vessels have OWS systems and use them to treat the discharge when CHT is not being practiced. While moored pierside in ports where shore facilities are available, LSD 41 Class vessels practice CHT by transferring bilgewater to a properly permitted shoreside facility. If shore facilities are unavailable, or the vessel is operating outside 12 nm, bilgewater is processed through an OWS and then discharged (See Section 8.3.2 on primary treatment OWS). Additional information on this MPCD is provided in the *Surface Vessel Bilgewater MPCD Screen-Control Device, MPCD Option Group: Collection, Holding, and Transfer* (Navy and EPA, 2001c).

8.3.5.1 Discharge Characterization Data

CHT does not directly release wastewater to the receiving waters within 12 nm. Refer to the Bilgewater ChAR for more information on the collection of characterization data (Navy and EPA, 2003).

8.3.5.2 Discharge Comparison to Criteria

Because CHT does not directly release wastewater to the receiving waters within 12 nm, no numeric or narrative WQC are exceeded in the receiving waters.

8.3.5.3 Discharge Toxicity (Hazard Index)

Because CHT does not directly release wastewater to the receiving waters within 12 nm, there is no liquid discharge to model, nor an HI to calculate at the EOMZ.

8.3.5.4 Non-Indigenous Species Release

Because CHT does not directly release wastewater to the receiving waters within 12 nm, the potential for the discharge to release NIS is nearly nonexistent.

8.3.5.5 Bioaccumulative Contaminants of Concern

Because CHT does not directly release wastewater to the receiving waters within 12 nm, essentially no BCCs are released.

8.3.5.6 *Constituent Mass Loading and Toxic Pound Equivalents*

Because CHT does not directly release wastewater to the receiving waters within 12 nm, this MPCD option has essentially no mass loading of constituents to the receiving waters; therefore, no TPEs were calculated.

8.3.5.7 *Other Potential Environmental Impacts*

The only potential direct impact identified for this MPCD within 12 nm would result from the mishandling of the collected bilgewater during the offloading and transfer to shore for disposal. The transferred bilgewater is treated at a properly permitted facility.

8.4 MPCD RANKING AND ASSOCIATED UNCERTAINTY

This section analyzes and ranks each MPCD option that passed the MPCD screen and was not determined to be infeasible in the Bilgewater FIAR (Navy and EPA, 2003) for Large Compression Ignition Ships (6000 tons of displacement or more). Included in this section is a discussion of uncertainty and its effect on the ranking of MPCDs.

The primary-treatment MPCD options for bilgewater in Large Compression Ignition Ships (6000 tons of displacement or more) are gravity coalescence, centrifuge, and hydrocyclone. For simplification, these MPCDs were combined and represented by gravity coalescence, as described in the Bilgewater ChAR (Navy and EPA, 2003). CHT is also a primary MPCD option for bilgewater. Membrane filtration and filter media are secondary-treatment MPCD options that can be used in conjunction with the gravity coalescence, centrifuge, or hydrocyclone MPCD options. As with primary treatment, secondary treatment options are represented in UNDS analysis by being combined with gravity coalescence. The term “treatment train” is used when describing combinations of primary and secondary treatment MPCD options.

To analyze the environmental effectiveness of a particular MPCD option or MPCD treatment train, the results of the environmental analysis were compared to:

- Number of exceeded WQC;
- Number of constituents exceeding the strictest criteria;
- HI toxicity analysis;
- Presence of BCCs;
- Constituent mass loading and TPEs;
- Potential to introduce NIS; and
- Other environmental effects.

8.4.1 Exceeded Water Quality Criteria

As discussed in the Bilgewater ChAR (Navy and EPA, 2003), there is wide variability in the composition of bilgewater. This variability is due to many factors, including variation in constituent sources (e.g., the occurrence of mechanical leakage), variation in processing rates, age of vessel and piping materials, and variations in equipment reliability. Due to these many factors, sampling was conducted only to take a “snapshot” of the bilgewater composition for the

discharge to complement available process knowledge. Uncertainty due to naturally occurring variability is the primary impediment of using sample data to rank MPCD options. Therefore process knowledge is the primary source of information for this ranking.

In addition to variability, questions of data accuracy contribute to uncertainty. One important source of accuracy relates to the data used to describe primary treatment plus filter media. As discussed in the Bilgewater ChAR (Navy and EPA, 2003), the data used to describe filter media performance are based on favorable conditions and therefore may not represent a long-term average.

Table 8-21 provides a comparison of constituent concentrations to WQC values for those constituents that exceed the strictest criterion.

Table 8-21. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge Constituent	Strictest WQC	Baseline	Primary Treatment	Primary Treatment Plus Filter Media ¹	Primary Treatment Plus Membrane Filtration ¹	CHT ²
Copper	2.4E+00	1.3E+01	1.5E+01	1.5E+01	8.1E+00	0
Iron	3.0E+02	3.4E+02	3.3E+02	1.3E+02 ³	5.8E+01 ³	0
Lead	5.6E+00	8.9E+00	9.8E+00	9.8E+00	ND	0
Manganese	1.0E+02	1.1E+02	1.1E+02	1.1E+02	1.2E+02	0
Mercury	2.5E-02	ND	ND	ND	2.0E-01	0
Nickel	8.3E+00	1.1E+02	1.1E+02	8.4E+01	3.4E+01	0
Zinc	5.0E+01	4.1E+02	4.5E+02	2.7E+02	1.9E+01 ³	0
Phenanthrene	5.0E+00	1.1E+01	1.1E+01	ND	ND	0
Thallium	6.3E+00	1.5E+01	1.2E+01	1.2E+01	1.2E+01	0
Total Aqueous Hydrocarbons	1.5E+01	7.4E+01	7.7E+01	7.7E+01	6.9E+01	0
Total Aromatic Hydrocarbons	1.0E+01	2.4E+01	2.5E+01	ND	2.0E+01	0
Ammonia as Nitrogen	2.3E+02	1.2E+03	1.3E+00	1.3E+03	5.4E+02	0
Number Of Constituents Exceeding Strictest WQC	-	11	11	8	8	0
Total Exceeded Numeric Criteria	-	76	73	68	32	0

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

² CHT does not release constituents to the receiving waters.

³ Does not exceed criteria.

ND = Not detected

Sample results do not indicate a substantial reduction in the number of constituents exceeding criteria or the total number of criteria exceeded after primary treatment. Although process knowledge indicates that the gravity coalescence will provide a reduction in certain constituent concentrations, this reduction is not realized in the criteria exceedance count for two reasons. As discussed previously, the naturally-occurring variability of bilgewater over time contributes to

uncertainty. In addition, the primary source of acute toxicity in this discharge is from metals. Each of the treatment technologies evaluated in this analysis were designed to remove petroleum hydrocarbons rather than metals, although some reduction may be achieved. The secondary treatment technologies did achieve a reduction in criteria exceedances. Although uncertainty sources can be identified, the exact amount of uncertainty in each value cannot be quantified. The exceedance counts, as one measure of environmental effect, support the following rankings.

MPCD ranking by numeric WQC exceeded:

1. CHT
2. Primary treatment plus membrane filtration
3. Primary treatment plus filter media
4. Primary treatment only

Table 8-22 provides a comparison of baseline and MPCD option characteristics to narrative WQC.

Table 8-22. Comparison of Narrative Water Quality Criteria for Baseline and MPCD Discharge Constituents for Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Narrative Constituent with Applicable Numeric Endpoint	Baseline	Primary Treatment	Primary Treatment Plus Filter Media ¹	Primary Treatment Plus Membrane Filtration ¹	CHT
BOD	Fail	Fail	Fail	Fail	Pass
Color	Fail	Fail	Pass	Fail	Pass
Floating Material	Pass	Pass	Pass	Pass	Pass
Nutrients	Fail	Fail	Fail	Fail	Pass
Odor	Fail	Fail	Pass	Fail	Pass
Oil and Grease (HEM)	Fail	Fail	Fail	Fail	Pass
Pathogens	Pass	Pass	Pass	Pass	Pass
Settleable Materials	Pass	Pass	Pass	Pass	Pass
Suspended Solids	Pass	Pass	Pass	Pass	Pass
Taste	Pass	Pass	Pass	Pass	Pass
Temperature	Pass	Pass	Pass	Pass	Pass
Turbidity/Colloidal Matter	Fail	Fail	Pass	Pass	Pass
Total Exceeded Narrative Categories	6	6	3	5	0

¹ Constituent Concentrations are calculated using methodology described in Putnam and Singerman (2001).

ND= Not Detected

MPCD ranking by narrative criteria involve less uncertainty than HI, TPE, and criteria exceedances because they rely less on constituent concentrations averaged over a few sampling events and more on process knowledge. The only difference among MPCD options in regard to narrative criteria exceedances is due to the color and odor results. Sampling results, supported by process knowledge, indicate that filter media technology will remove color and odor effectively.

MPCD ranking by narrative WQC exceeded:

1. CHT
2. Primary treatment plus filter media
3. Primary treatment plus membrane filtration
4. Primary treatment only

8.4.2 Discharge Hazard Index

The UNDS program incorporates an HI approach as a means of estimating the aggregate acute toxicity of a discharge. This estimate is made by first applying a modeled dilution factor to EOP constituent sample data. The HQs are determined by dividing the product by the constituent-specific toxicological endpoint concentration (TEC). The HI is the summation of these quotients, which is used to estimate acute marine aquatic-life toxicity at the EOMZ. This analysis method is described in the EEA guidance manual (Navy and EPA, 2000e). For more information on the HI method, see the *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards* (Navy and EPA, 2001f).

The uncertainty of HI values is primarily based on the uncertainty in sample data, compounded by approximations made in the computer-based modeling of the liquid discharge. For more information about the UNDS modeling method, see the *Technical Approach for Pierside Modeling to Support UNDS EEA Phase II* (Navy and EPA, 2001e).

Table 8-23 provides the calculated HI values for the baseline discharge and MPCD options as well as the EOMZ HQs for the COCs.

Table 8-23. Comparison of Constituent of Concern Hazard Quotients and Total Discharge Hazard Indices at Edge of Mixing Zone in Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge Constituent	Baseline	Primary Treatment	Primary Treatment Plus Filter Media ¹	Primary Treatment Plus Membrane Filtration ¹	CHT
Cadmium	3.0E-03	3.0E-03	3.0E-03	ND	0
Copper	2.2E+00	2.0E+00	1.0E+00	1.0E-01	0
Iron	6.0E-02	5.8E-02	2.3E-02	1.0E-02	0
Lead	2.3E-03	2.5E-03	2.5E-03	ND	0
Manganese	5.7E-02	5.7E-02	5.7E-02	6.3E-02	0
Mercury	ND	ND	ND	6.0E-03	0
Nickel	8.1E-02	8.1E-02	6.0E-02	2.4E-02	0
Nitrate/Nitrite	2.2E+00	2.6E+00	1.5E+00	ND	0
Oil and Grease (HEM ²)	1.7E+00	1.4E+00	4.1E-01	8.1E-01	0
Selenium	1.3E-03	1.3E-03	1.3E-03	6.7E-04	0
Sulfate	8.3E-01	8.2E-01	8.2E-01	7.4E-01	0

Discharge Constituent	Baseline	Primary Treatment	Primary Treatment Plus Filter Media ¹	Primary Treatment Plus Membrane Filtration ¹	CHT
Thallium	1.3E-01	1.0E-01	1.0E-01	1.0E-01	0
Total Sulfide	8.4E+00	7.4E+00	ND	6.1E+00	0
Zinc	2.4E-01	2.6E-01	1.6E-01	1.1E-02	0
Total Discharge HI	1.6E+01	1.5E+01	4.2E+00	8.0E+00	0

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

² HEM TEC value was based on the fuel/lube TEC. For more information, see Development of TECs for Categories Derived from Petroleum and Foods (Navy and EPA, 2001g).

ND = Not Detected

Despite the degree of uncertainty in the sample data due to naturally occurring variability and the fact that the MPCD options being considered were not designed to treat a primary source of acute toxicity in the discharge (i.e., metals), the differences among HI values for treatment options are discernible. However, uncertainty due to potential inaccuracies of filter media performance because of channeling suggests that the filter media may not provide the environmental performance evidenced by these results. Analysis results support the following rankings.

MPCD ranking by discharge HI:

1. CHT
2. Primary treatment plus filter media
3. Primary treatment plus membrane filtration
4. Primary treatment only

8.4.3 Non-Indigenous species

All of the MPCD options, with the exception of CHT, are relatively equal when considering the potential to introduce NIS to the receiving waters. CHT has essentially no potential for release because there is no direct discharge to the receiving waters inside 12 nm. The potential for the baseline discharge to introduce NIS is expected to be low because “*there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances*” (EPA and DoD, 1999).

MPCD ranking by potential to release NIS:

1. CHT
2. Primary treatment plus membrane filtration, or primary treatment plus filter media
3. Primary treatment only

8.4.4 Bioaccumulative Contaminants of Concern

Table 8-24 provides a comparison of the number of elimination and reduction BCCs identified in the discharge across MPCDs. BCCs in the discharges are also indicated by an asterisk (*) in Appendices A and B.

Table 8-24. Comparison of Bioaccumulative Contaminants of Concern Identified in Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge	Elimination BCCs	Reduction BCCs	Total BCCs
Collection, Holding, and Transfer (CHT)	0	0	0
Primary Treatment plus Membrane Filtration ¹	1	4	5
Primary Treatment plus Filter Media ¹	2	3	5
Primary Treatment	2	5	7
Baseline discharge	2	5	7

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

Uncertainty in the ranking of MPCD options by BCC count is due to the same factors identified previously. The primary source of uncertainty is naturally occurring variability (as discussed in Section 8.4.1).

MPCD ranking by presence of BCCs:

1. CHT
2. Primary treatment plus membrane filtration, primary treatment plus filter media
3. Primary treatment only

8.4.5 Constituent Mass Loading and Toxic Pound Equivalents

As discussed in the EEA guidance manual (Navy and EPA, 2000e), mass loading and TPEs were calculated for each discharge constituent. Both the mass loading and TPE calculations are functions of the constituent concentrations and annual discharge volumes. The uncertainty associated with the constituent concentration values is due to the naturally occurring variability in bilgewater composition, as described in Section 8.4.1.

As discussed in the Bilgewater ChAR (Navy and EPA, 2003), the UNDS Phase I Surface Vessel Bilgewater/OWS Nature of Discharge report (NOD) estimates that the average in-port generation rate for a LSD Class vessel is approximately 2,500 gal/day (EPA and DoD, 1999). However, actual performance data indicates the generation rate is 10,000 gal/day underway (Navy, 1997). Additionally, the five vessel classes that comprise this vessel group vary in vessel size, machinery, and displacement. Bilgewater generation rates depend on ship size and propulsion plant type. As a result, having multiple vessel classes results in more variation in generation rates and these variations reflect the uncertainty associated with these values.

For more information about the uncertainty associated with the generation rates, see the Bilgewater ChAR (Navy and EPA, 2003). The ChAR provides details on the assumptions made to determine the generation rate; specifically, that all of the bilgewater generated pierside is discharged overboard. In practice, however, bilgewater generated by the LSD 41 Class vessels is typically treated at a shoreside facility.

Mass loading data for the baseline discharge and each MPCD option are summarized in Table 8-25.

Table 8-25. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) in Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge Constituent	Baseline	Primary Treatment	Primary Treatment Plus Filter Media ¹	Primary Treatment Plus Membrane Filtration ¹	CHT ²
Cadmium	9.0E-01	9.2E-01	9.2E-01	ND	0
Copper	7.7E+01	7.1E+01	3.6E+01	3.6E+00	0
Iron	1.3E+02	1.3E+02	ND	ND	0
Lead	3.4E+00	3.8E+00	3.8E+01	ND	0
Manganese	4.1E+01	4.2E+01	4.2E+01	4.6E+01	0
Mercury	ND	ND	ND	7.9E-02	0
Nickel	4.3E+01	4.3E+01	3.3E+01	1.3E+01	0
Nitrate/Nitrite	1.1E+03	1.3E+03	7.8E+02	ND	0
Selenium	2.8E+00	2.7E+00	2.7E+00	1.4E+00	0
Thallium	6.0E+00	4.6E+00	4.6E+00	4.6E+00	0
Zinc	1.6E+02	1.7E+02	1.0E+02	7.2E+00	0
Naphthalene	5.1E+00	5.6E+00	ND	7.7E+00	0
Phenanthrene	4.4E+00	4.2E+00	ND	ND	0
Ammonia as Nitrogen	4.8E+02	5.0E+02	5.0E+02	2.1E+02	0
Sulfate	1.9E+05	1.9E+05	1.9E+05	1.7E+05	0
Total Sulfide	1.2E+03	1.0E+03	ND	8.4E+02	0

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

² CHT does not release constituents to the receiving waters.

ND = Not Detected

MPCD options were not ranked by mass loading values because they would have to be ranked for every constituent separately. In order to capture the net chronic toxic effect of each constituent's mass loading contributions, the relative toxicity of each constituent would have to be weighted. In order to achieve a relative ranking, TPEs were utilized. Table 8-26 provides the TPE for the baseline discharge and MPCD options for this vessel group.

Table 8-26. Comparison of Toxic Pound Equivalents for the Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

Discharge	Toxic Pound Equivalent
Collection, Holding, and Transfer (CHT)	0
Primary Treatment plus Filter Media ¹	3.4E+02
Primary Treatment plus Membrane Filtration ¹	2.5E+03
Baseline Discharge	3.7E+03
Primary Treatment	3.3E+03

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

The total discharge TPE does not include the chronic toxicity contribution from oil and grease (HEM) constituents, however, because the individual constituents of this fraction vary by products entering the bilge and the degree of product weathering before discharge. The chronic toxicity contributions were therefore evaluated by comparing to HQ and HI results. As discussed in Sections 8.3.1.6, 8.3.2.6, 8.3.3.6, and 8.3.4.6, oil and grease (HEM) constituents are assumed to contribute up to 11 percent of total chronic toxicity in discharges, based on acute toxicity (HI) determinations.

Overall, TPE calculations for the baseline and MPCD options indicate that the filter media secondary treatment option was shown to reduce the TPE by approximately 91 percent overall; the membrane filtration secondary treatment option was shown to reduce the TPE by approximately 32 percent.

MPCD ranking by TPE:

1. CHT
2. Primary treatment plus filter media
3. Primary treatment plus membrane filtration
4. Primary treatment only

8.4.6 Other Potential Environmental Impacts

Most MPCDs create two waste streams: the aqueous fraction that is discharged overboard following treatment and the oil fraction that is directed to the on-board waste-oil holding tank. The oil fraction is treated at a properly permitted facility and subject to applicable Federal, State, and local disposal regulations. The use of filter media creates an additional waste in the form of used filters. Disposal of these used components is subject to Federal, State, and local disposal regulations. For purposes of this analysis, the disposal of these discharges is assumed to comply with applicable regulations. The MPCD options described in this analysis of bilgewater are therefore ranked as equivalent options in terms of other environmental impacts.

8.4.7 Conclusion

The results of the EEA for the baseline and MPCD bilgewater discharges from Large Compression Ignition Ships (6000 tons of displacement or more) are summarized in Table 8-27.

Table 8-27. Summary of EEA for Baseline and MPCD Discharges from Large Compression Ignition Ships (6000 tons of displacement or more) (LSD 41)

	Baseline Bilgewater	Primary Treatment	Primary Treatment Plus Filter Media ¹	Primary Treatment Plus Membrane Filtration ¹	CHT
Number of Constituents exceeding strictest WQC	11	11	8	8	0
Total Number of Exceeded Numeric WQC	76	73	68	32	0
Number of Exceeded Narrative Categories	6	6	3	5	0
Discharge HI at EOMZ	1.6E+01	1.5E+01	4.2E+00	8.0E+00	0
Potential for NIS Release	Low	Low	Low	Low	None
Number of BCCs Identified	7	7	5	5	0
Discharge TPE	3.7E+03	3.3E+03	3.4E+02	2.5E+03	0

¹ Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options provide bilgewater treatment performance that is superior for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. Primary treatment plus membrane filtration ranked ahead of filter media in regard to criteria exceedances, but resulted in a higher TPE value. However, uncertainty due to potential inaccuracies of filter media performance because of channeling (see Section 8.4.1) suggests that the filter media may not provide the environmental performance evidenced by these results. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration, primary treatment plus filter media
3. Primary treatment only